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ABSTRACT

A study examining the effects of systematized feedback on mathematics performance was conducted in natural classroom settings to extend the external validity of previous feedback studies. A posttest-only, internal-external control group design was used with three sixth grade classes serving as subjects. All classes utilized a "step" approach to math instruction, where students advanced through a pre-determined sequence of math skills at individual rates. Two classes, each taught by the same teacher, were used to measure treatment effects. One class served as an internal control group, receiving only math instruction. The other class received math instruction and systematized feedback. The remaining class, taught by a different teacher, served as an additional external control class. It was included to control for possible teacher bias and received only math instruction. At the end of 12 weeks, all students were administered a 25-item test. A comparison of the scores of the three classes indicated that feedback is of significant value when applied in a systematic manner. The study confirmed the effectiveness and practicality of feedback based programs in "real world" settings. (Author/LLS)

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SYSTEMATIZED FEEDBACK AND MATHEMATICS PERFORMANCE

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Paper presented at the annual meeting of the Association for Educational Communication and Technology (AECT) - Research and Theory Division, Denver, Colorado (April, 1980).

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ABSTRACT

Feedback programs have produced inconsistent effects on student performance. The major contributing factors have been inconsistent definitions of feedback and feedback procedures used in various studies. Variations in the feedback recipients (students, teachers, parents) and a lack of careful utilization of the instructional content in the feedback systems have also contributed to the reported inconsistencies. In addition, feedback programs have been criticized as being unrealistic in non-laboratory settings. Many programs have not adequately considered the problems presented in typical classroom settings, and have imposed relatively complex feedback programs in contrived classrooms. Systematized feedback, a curriculum- based program employed in the present study, was defined as providing knowledge of results of student performance to both students and teachers: a) related to established instructional objectives; b) within an established instructional context; and c) on a regularly prescribed basis.

A posttest-only, internal-external control group design was used in the present study. Three sixth grade classes served as subjects. All classes utilized a "step" approach to math instruction, where students advanced through a pre-determined sequence of math skills at individual rates. Two classes, each taught by the same teacher, were used to measure treatment effects. One class served as an internal control group, receiving only math instruction. The other class received math instruction and systematized feedback. The remaining class, taught by a different teacher, served as an additional external control class. The external control class, included to control for possible teacher bias, received only math instruction.

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The systematized feedback class was administered a math skill inventory to determine the individual skill status of each student. Student scores were provided to the teacher, who subsequently distributed the results to the students. Students individually recorded their skills as mastered, instructional, or not mastered on skill profile sheets. Students were instructed for a two week period, and administered an update quiz which covered skills not yet mastered. Student quizzes were scored, returned to the teacher for review, and subsequently distributed to the students for feedback and profile updating. This procedure continued for twelve weeks. All students were administered a 25 item math computation proficiency test at the end of the twelve week period.

Results of an ANOVA comparing the scores of the three classes indicated significant differences ($p<.02$). Means and standard deviations for the three classes were: systematized feedback ($\bar{X}=21.20$; S.D.=3.07), internal control ($\bar{X}=18.75$; S.D.=3.67), and external control ($\bar{X}=18.61$; S.D.=3.47). The systematized feedback class scored significantly higher than the control groups on the math proficiency test, while no significant differences were obtained between the two control groups. The observed treatment effect and the non-significant differences between the control classes suggests that the results are valid, and not simply a function of teacher bias.

Feedback is of significant value when applied in a systematic manner. The present study confirms the effectiveness and practicality of feedback based programs in "real world" settings. Feedback programs should systematically include instructional content, feedback procedures that include both teachers and students, and provisions for assuring compatability with existing instructional settings.

SYSTEMATIZED FEEDBACK AND MATHEMATICS PERFORMANCE

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The benefits of providing delayed feedback in the instructional process have been well documented in controlled settings (Sturges, Sarafino, and Donaldson, 1968; More, 1969; Kulhavy, 1972; Sassenrath, 1975). Yet comparatively little research demonstrating applicability of delayed feedback in natural classroom settings has been reported. Limited attempts to apply delayed feedback programs in natural classroom settings have often produced contradictory results (e.g., Surber & Anderson, 1975, versus Newman, Williams, & Hiller, 1974). The determination of the practical effectiveness of delayed feedback in natural classroom settings is imperative.

The present study examined the effects of providing delayed, systematized feedback on student test scores on math computation proficiency tests. Delayed systematized feedback was defined as providing knowledge of test results on skill quizzes to both students and teachers: a) related to established instructional objectives; b) within an established instructional context, i.e., natural classroom setting; c) on a bi-weekly basis; and d) one day following the completion of the quiz.

Several important components of delayed feedback programs have been identified. Sturges (1972 a) suggested that the effecitveness of delayed feedback programs is contingent on the nature of the stimuli present during the feedback, how the students or subjects respond to the feedback, and the relevance of the feedback stimuli to the test measures. Kulhavy (1977) noted that although feedback should be used frequently in the instructional process, the availability of feedback materials needs to be restricted.

He reasoned that when feedback materials are too readily available, students might copy responses rather than utilizing the correcting function of feedback to confirm the accuracy of their responses. Kulhavy also suggested that the instructional level upon which the feedback is based must be appropriate for the intended learners. Feedback systems produce only minimal effects when students have very little confidence in their responses. Consequently, the required learning tasks must be reasonably attainable for delayed feedback strategies to be effective (Kulhavy, 1977). Sturges (1972 b) suggested that the activity immediately following feedback is also critical in feedback programs. Given opportunities for self-correction or practice following feedback, students' performance was improved as a result of the feedback (Sturges, 1972 b). In effect, the identified components suggest that feedback must be systematically applied in order to be maximally effective.

The manner in which delayed feedback is operationally defined is also an important factor. Delayed feedback has been frequently defined as providing knowledge of results of test performance to students. However, the different ways in which such definitions have been operationalized have been a source of concern. Kulhavy (1977) attributed many of the reported inconsistencies among delayed feedback programs to operational definitional differences.

The manner in which knowledge of results is provided has also been considered an additional source of potential variability. Sturges (1969) noted that knowledge of results in delayed feedback programs should be informative, i.e., must include information related to criterion measure items and response alternatives. Gilman (1969) has suggested that the process of providing knowledge of results be modified to provide greater

guidance to the learners. The author found that feedback which simply identifies responses as correct or incorrect was not as effective as providing knowledge of results with guided elaboration. Guided elaboration, where both correct and incorrect responses are verified through a structured review of the relevant content, was more effective in improving student performance than providing only knowledge of response accuracy (Gilman, 1969).

An additional definitional problem reported in feedback literature is related to the immediate vs. delayed feedback dichotomy. Since the terms immediat e and delayed are relative terms, they have been operationally defined within each individual study. Consequently, the generalizability of research findings has been somewhat limited (Peck & Tillema, 1979, Note 1).

Attempts have also been made to identify maximally effective delay intervals as applied in delayed feedback programs. Studies employing delayed feedback techniques have focused primarily on retention of factual information. Research in written prose learning generally indicates that feedback delays from one-to-two days are effective in improving subsequent student performance. English and Kinzer (1966) found that feedback delays of one hour or two days were superior to either immediate feedback or feedback delayed one week. More (1969) found that delays of two-and-one-half hours or one day were superior to either immediate feedback or feedback delayed four days. However, the primary means for assessing student performance in these studies has been the use of multiple choice tests. The effectiveness of feedback programs in process-oriented content areas has not been well documented. Computational mathematics, for example, requires both basic factual memory and process-oriented applica-

tions. Existing feedback research does not provide clear guidelines for the development of feedback programs process-oriented content areas such as mathematics.

The use of feedback systems in relearning information is also an important consideration. However, the manner in which feedback information should be subsequently utilized has not been clearly established. While this is critical to the development of an effective feedback program, research has not conclusively identified how feedback information should be subsequently utilized in order to be maximally effective. Surprisingly little research has been reported pertaining to the role of the instructor in teacher-directed learning settings. In such settings, the teacher typically controls the content, presentation rate, and total time provided for instruction. Since these are potent variables in facilitating student learning, the role of the teacher needs to be investigated.

Method

Subjects

The subjects were 67 students assigned to one of three sixth grade mathematics classes in a non-tracked suburban elementary school. Non-tracked refers to the essentially random class assignment procedures used by the school system. The three classes were selected because each used a "step" approach to mathematics instruction, where students advanced through a predetermined sequence of mathematics skills at individual rates. Two classes were taught by the same teacher, and the remaining class was taught by a second teacher. One class was the systematized feedback group, one the internal control group, and one the external control group.

Materials

The materials used in the present study included a mathematics skill inventory, a series of sequenced mini-quizzes, student profile sheets for recording individual progress, and class record sheets for reporting overall class progress. The mathematics inventory included three test items for each of 39 specific objectives. The objectives were developed and sequence by school personnel prior to the present study and the mathematics inventory was developed by the researcher for the present study. The inventory provided information used to establish the baseline skill status for each student in the systematized feedback group. The mathematics inventory also served as the initial feedback instrument for both teachers and students regarding individual skill acquisition. Thirty-nine separate mini-quizzes, each keyed to the mathematics objectives, were used for a bi-weekly skill assessment of students in the systematized feedback group. Student performance on the mini-quizzes was the primary information source for providing the bi-weekly feedback. In addition, each student in the systematized feedback group maintained an individual skill profile sheet which included the 39 math objectives. Students individually recorded their skills as mastered (100% accuracy), instructional (67% accuracy), or not mastered (less than 67% accuracy) on their profile sheets. The skills were sequentially ordered from easiest to most difficult based upon the skill sequence defined by the school personnel. The individual skill profile sheets provided students with the means to monitor their individual progress throughout the study. Based upon individual student performance on the bi-weekly mini-quizzes, students individually updated their profiles. A class summary record sheet, which provided a student performance by objective format, provided a capsulized summary of student performance and

progress throughout the study.

Criterion Measures

The criterion test used in the present study was a 25 item mathematics computation test. The computation test included skills which are typically mastered between fifth and eighth grade levels, and all skills on the computation test were also included on the mathematics inventory and mini-quizzes. The test required addition, subtraction, multiplication, and division of whole numbers, fractions, and decimals. In addition, test items related to physical geometry and measurement were included. The test, which was developed by the school staff, was administered to provide information for the present study and information for use in subsequent class scheduling. The test was a constructed response test, and was administered as a power test.

Procedures

Three classes participated in the study. Two classes were taught by the same teacher, the remaining class was taught by a different teacher. Of the two classes taught by the same teacher, one class was randomly assigned to the systematized feedback treatment. The remaining classes served as control classes.

Prior to the start of the study, the systematized feedback teacher provided students with a general introduction to the mathematic program that followed. No statement was made regarding comparisons among classes; students were not informed that their test scores would be compared with the performance of other classes. Students were administered the mathematics inventory under untimed conditions prior to the start of the program. Mathematics inventories were scored, student performance was recorded on the class record sheet and student profile sheets, and all information was

returned to the teacher on the first day of the program. The teacher distributed the student profile sheets to the class with the corresponding scored mathematics inventory test. At that time, the teacher conducted a 15 minute orientation session designed to familarize the students with the relationship between their test performance and their individual profile sheets. The teacher provided instructions to the students for recording their test scores during the subsequent feedback periods provided during the study. All students then received instruction for a two week period. At the end of the two week period, students in the systematized feedback class were administered mini-quizzes covering those skills not yet mastered. Since many students had not yet been exposed to several of the more difficult skills, they were instructed to review each test item, write their answers if they felt reasonably confident they could perform the task, or mark an "X" in the answer box if they were uncertain of the correct response. The mini-quizzes were corrected, scored, and returned to the teacher and the students on the next school day. At that time, the teacher distributed the scored mini-quizzes to the students and instructed them to update their profile sheets according to the quiz results. Students were provided approximately five minutes for completing this task. The teacher then instructed the students to review their correct and incorrect answers in order to identify possible problems. Students were told to request assistance from the teacher, if needed, or to proceed with the next step in the mathematic sequence. Since students in all classes were routinely instructed to request needed assistance, this procedure simply confirmed the availability of the teacher under the new program.

The bi-weekly testing, scoring, and feedback was continued throughout a twelve week period. At the end of the twelve week period, students in

both the systematized feedback class and the control classes were administered the 25 item mathematics computation test.

Results

Means and standard deviations for the mathematics computation test scores by treatment group are included in Table 1.

Insert Table 1 Here

As shown in Table 1, the systematized feedback class scored higher than either the internal control class or the external control class. Results of a one-way ANOVA indicated the difference to be significant ($F=4.18, df = 2/64, p<.02$). No significant differences were obtained between the two control groups.

Discussion

The present study examined the effects of systematized feedback on mathematics performance. The study was conducted in natural classroom settings in an attempt to extend the external validity of previous feedback studies.

The results of the present study indicate that feedback can be of significant value when applied in a systematic manner. All classes employed in the present study employed the same instructional materials, approximately the same student entry level skills based on teacher and administrator report,

Table 1

Mean Computation Test Scores, N, and Standard Deviations by Treatment Group

Computation Test Results	Treatment Group		
	Systematized Feedback	Internal Control	External Control
Test Score	21.20*	18.75	18.61
S.D.	3.07	3.67	3.49
N	24	20	23

*p<.02

and the same performance documentation system required by the school. The major departures among the classes employed in the present study were that the systematized feedback class employed an instructionally integrated feedback system. Systematized feedback was regularly provided, organized, included provisions for post-feedback instruction, and was provided to both students and teachers.

In effect, systematized feedback provides a closed loop instructional system where knowledge of student performance is sensibly integrated with instruction and assessment to improve subsequent student performance. Since the major difference between the systematized feedback class and the control classes was essentially organizational in nature, the findings suggest that a more methodical approach to providing instruction in natural settings is both plausible and effective.

During the present study, no special requirements were made of the systematized feedback teacher regarding instructional style. The teacher was instructed to use the information in whatever manner deemed appropriate. However, as verified informally by the teacher, teaching style was modified as a result of the systematized feedback received during the study. The systematized feedback teacher indicated that the instruction became more focused, i.e., more skill-specific. Also, the teacher noted that student progress became contingent on demonstrable skill acquisition rather than teacher judgement. While it is impossible to partition the proportion of score variance accounted for by student versus teacher knowledge of results in the present study, the combined effect is apparent. When a teacher was provided meaningful information upon which to base modifications in teaching style, changes occurred; when such information was provided on a regular basis, as demonstrated during the present study, the teacher modified

instructional strategies on an on-going basis. The result of this type of on-going instructional modification was inevitably improved student performance. Since the teacher possesses substantial control over the instructional process, the importance of including the teacher in delayed feedback programs can not be overstated. While the student is ultimately responsible for learning the information presented, the teacher typically controls what and how information is to be presented.

Several cautions which are frequently encountered in applied, action research must be considered. Although random assignment of students to classes was assumed no absolute statements of pre-program equivalence among classes can be guaranteed. Historically, however, substantial mathematics performance differences among sixth grade classes was considered very uncommon by the school administration. Also, since the researcher randomly assigned the systematized feedback class, potential teacher or subject selection bias was not a factor. Future research should systematically account for equivalence through pretest procedures or covariance techniques.

In some respects, the strengths of the present study might be perceived as the weaknesses of a more rigidly controlled study. In the present study, however, the external validity of the controlled delayed feedback research was of particular concern. The present study confirms the effectiveness and practicality of feedback based programs in "real world" settings.

Additional research regarding the generalizability of delayed feedback research to other process-oriented subject areas should be advanced. Although computational mathematics is largely process in nature, the present study utilized a fairly well articulated instructional system. It is unclear whether or not academic subjects involving literature or creative writing are equally amenable to a systematized feedback approach.

An additional area for further research concerns the effects of systematized feedback on task-relevant student questioning. It is possible that systematized feedback increases the number of task-relevant questions due to the information available for student review. However, it is also possible that student questionning would be reduced as a function of the preciseness and task relevance of the information provided during systematized feedback. Such possibilities should be investigated.

In summary, feedback is of significant value when applied in a systemtic manner. The present study confirms the effectiveness and practicality of systematically applied feedback in natural classroom settings. Feedback programs should systematically include instructional content, feedback procedures that include both teachers and students, and provision for assuring compatability within the instructional setting.

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